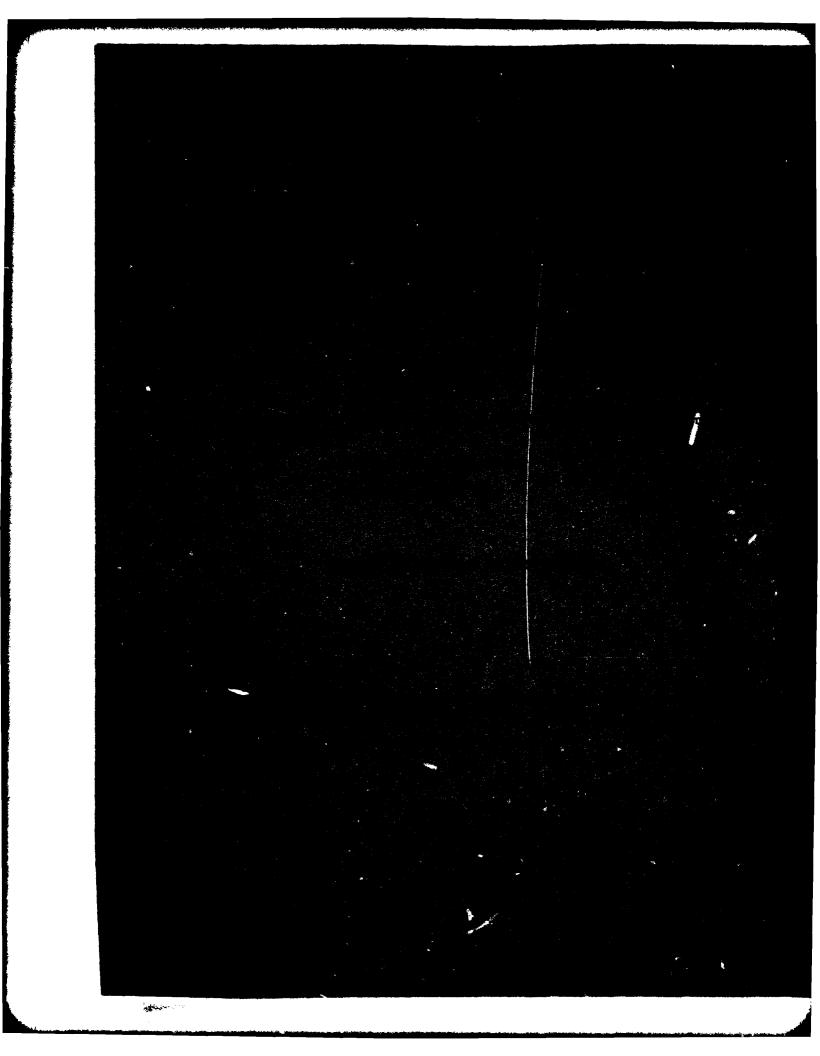


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overall and band sound pressure levels, C-weighted and A-weighted sound levels, preferred speech interference level, perceived noise level, and limiting times for total daily exposure of personnel with and without standard Air Force ear protectors. Far-field data measured at 19 locations are normalized to standard meteorological conditions and extrapolated from 75-8000 meters to derive sets of equal-value contours for these same seven acoustic measures as functions of angle and distance from the source. Refer to Volume 1 of this handbook, "USAF Bioenvironmental Noise Data Handbook, Vol 1: Organization, Content and Application", AMRL-TR-75-50(1) 1975, for discussion of the objective and design of the handbook, the types of data presented, measurement procedures, instrumentation, data processing, definitions of quantities, symbols, equations, applications, limitations, etc.

# **PREFACE**

This report was prepared by the Biodynamic Environment Branch, Aerospace Medical Research Laboratory, under Project/Task 723107, Technology to Define and Assess Environmental Quality of Noise From Air Force Operations.

The author gratefully acknowledges Mr. John Cole and Mr. Robert Powell for their assistance in preparing this report, Mr. Jerry Speakman and Capt Richard Gorman for their assistance in acquiring the raw data, Mr. Keith Kettler, Mr. Henry Mohlman and Mr. Fred Lampley of the University of Dayton for assistance in the mechanics of data processing, and Mrs. Peggy Massie for assistance in typing this report.

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#### INTRODUCTION

The F-16 is a single seater, multi-purpose fighter powered by one Pratt and Whitney F100-PW-100 engine. The aircraft is manufactured by General Dynamics. The AF32A-25 noise suppressor was built by Jetway Corporation to provide noise level reduction for all F-16 aircraft during ground runup operations.

This volume provides measured and extrapolated data defining bioacoustic environments produced by this aircraft during ground runup operations. Such data are essential to evaluate ear protection requirements, limiting personnel exposure times, voice communication capabilities, and annoyance problems associated with ground runups of the F-16 aircraft operating in the AF32A-25 noise suppressor.

This volume is one of a series published by the Aerospace Medical Research Laboratory (AMRL) under the same report number (AMRL-TR-75-50) as a multi-volume handbook that quantifies the noise environments produced at flight/ground crew locations and in surrounding communities by operations of Air Force aircraft and ground support equipment. The far-field, community-type noise data in the handbook describe the noise produced during ground operations of aircraft, ground support equipment, and other ground-based equipment or facilities.

Volume 1 of this handbook discusses the objectives and design of the handbook, the types of data presented, measurement procedures, instrumentation, data processing, definitions of quantities, sumbols, equations, applications, limitations, etc. Volume 2 provides a method and data for adjusting the handbook's far-field noise data, which are for standard meteorological conditions (15°C temperature, 70% rel humidity, 0.760 meters Hg barometric pressure), to derive comparable data for other meteorological conditions. Refer to Volumes 1 and 2 (references 1 and 2) for such information because it is not repeated in other handbook volumes.

A cumulative index lists those aerospace systems contained in the handbook, and identifies the specific volumes containing each type of environmental noise data available (i.e., inflight/flight crew and passenger noise, near-field/ground crew noise, far-field/community noise). Volume numbers are assigned sequentially as individual volumes are published. This index is periodically updated as individual volumes are published and is available upon request from AMRL/BBE, Wright-Patterson AFB, OH 45433. Organizations on the distribution list for the handbook will automatically receive a copy of each updated index.

Direst any questions concerning the technical data in this report and other handbook volumes to: AMRL/BBE, Wright-Patterson AFB, OH 45433; AUTOVON 78-53675 or 78-53664; Commercial (513) 255-3675 or (513) 255-3664.

<sup>1.</sup> Cole, John N., USAF Bioenvironmental Noise Data Handbook, Volume 1: Organization, Content and Application, AMRL-TR-75-50 (1), Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, 1975.

<sup>2.</sup> Cole, John N., USAF Bioenvironmental Noise Data Handbook, Volume 2: Procedure to Evaluate Effects of Non-standard Meteorological Conditions on Far-Field Noise, AMRL-TR-75-50 (2), AMRL, WPAFB, OH, 1975.

## **NEAR-FIELD NOISE**

#### **MEASUREMENTS**

AMRL acquired near-field noise data on the AF32A-25 noise suppressor system during ground runup operations of F-16 aircraft. For these tests the aircraft was located in the suppressor at Hill AFB with no significant reflecting surfaces in the vicinity except the ground plane. Table 1 gives the surface meteorological conditions and the four engine power conditions. The ground-crew chief selected power conditions and near-field locations generally used during routine maintenance or engine runup for preflight checks.

At each near-field location a test engineer randomly moved a hand-held microphone in and around each location, probing all areas where a crew member's head would normally be located. He recorded all the noise samples on magnetic tape. During analysis of each sample, he determined the one-third octave band root-mean-square sound pressure using a 4- or 8-second integration time to derive a power averaged level for each location. Figure 1 shows the four near-field locations where ground crew are usually located for maintenance and/or preflight checkout operations. Estimates of noise levels at other locations are difficult in the near-field since the noise source is spatially distributed, i.e., not a point source. The noise levels at near-field locations can vary widely depending upon relative distances from each noise source (intake noise, exhaust noise, panel resonances, internal engine noise through the engine wall, etc.).

Table 1 lists the numeric alphabetic designators used on the data pages in this report to identify the measurement locations and test conditions. For example, the designator 1/A means ground crew location 1 and test condition A.

#### RESULTS

The measured data presented in Table 2 define the sound pressure levels (SPL) produced by the F-16 aircraft in the AF32A-25 noise suppressor at the three ground crew locations. This table includes the overall, 1/3 octave band, and octave band levels. From these data one can calculate the variety of measures given in Table 3, which are widely used to assess the effects of noise on personnel and their performance.

All near-field data are for the meteorological conditions at the time of test but are valid for all typical airbase meteorology because of the short sound propagation distances involved.

# TABLE 1

# MEASUREMENT LOCATIONS AND TEST CONDITIONS FOR NEAR-FIELD NOISE MEASUREMENTS

F-16 Aircraft Suppressor Ground Runup, Hill AFB Survey
Test #79-738-001, 14 March 1979

Ground Crew Location	
1.	Trim Check Position
2.	Leak Check Position
3.	<b>Ground Observer Position</b>
Aircraft Engine Operation	
Å.	Idle Power (65% RPM)
В.	80% RPM
C.	Military Power (91% RPM)
D.	Afterburner Power
Meteorology	
Temperature	12 C
Bar Pressure	.643 M Hg
Rel Humidity	32 %
Wind — Speed	4 M/Sec (8 Kt)
- Direction	110 <b>Deg</b>

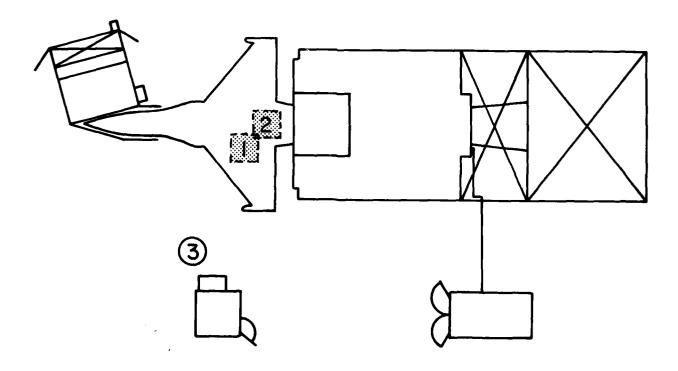


Figure 1. Near-Field Measurement Locations at Hill AFB, Utah

#### **FAR-FIELD NOISE**

## **MEASUREMENTS**

AMRL acquired both near and far-field data during a 1- 2-hour test period, thus keeping similar meteorological conditions. Figure 2 shows the ground runup pad, ground cover, aircraft orientation and the 19 microphone measurement sites on a semicircle. The center of the 100 meter radius semicircle used in surveying the AF32A-25 noise suppressor was on the ground directly below the center of the exhaust stack.

Table 4 provides cockpit readouts of engine characteristics (% RPM, fuel flow, etc.) for each power setting used in the far-field tests. Also listed in this table are the surface meteorological conditions during data acquisition.

All microphone measurement sites are in the acoustic far-field of their source where the sound wave-fronts spherically diverge and the noise source may be regarded as a point source.

A portable microphone/tape-recorder system was used to sequentially record the noise at each far-field location. The microphone was attached to a hand held pole, pointed at the source (0° angle of incidence) and vertically scanned from 0.5 to 3 meters for a period of 5-10 seconds during data acquisition at each microphone location. These samples were then time-integrated to derive a root-mean-square sound pressure level. Vertical scanning and time-integrating together reduce anomalies frequently present in data acquired by a fixed height microphone.

#### RESULTS

Table 5 lists the overall and 1/3 octave band SPL measured at the far-field locations under meteorological conditions at the time of the test. Data in all other figures and tables are based on these levels. These data were normalized to 100 meters distance and standard meteorological conditions (15°C temperature, 70% relative humidity, 0.760 meter Hg barometric pressure) and used to derive the graphic data in Figure 3 which provides a compact summary of the far-field noise characteristics of the F-16 aircraft operating in the AF32A-25 noise suppressor in a standard format.

Estimates of the noise levels for intermediate power settings (e.g., 85% RPM) and/or different number of engines operating (e.g., single engine) can be determined as explained in Volume 1 of this handbook.

Figures 4 through 10 are sets of equal noise contours describing seven different measures of noise as a function of angle and distance from the source for standard day meteorology. They are respectively, overall sound pressure level, C-weighted sound level, A-weighted sound level, perceived noise level, speech interference level, permissible exposure times for personnel and octave band sound pressure levels.

Data excessively influenced by spurious background/electronic noise were eliminated from all figures and tables.

Test personnel performed noise surveys during quiet periods when the background noise was minimal, e.g., early in the morning when no other aircraft or engine test stands were operating. Data eliminated because they were near the background/electronic noise were generally not significant because the levels were so low.

Volume 2 of the handbook describes the influence of meteorology on far-field noise en ronments, and provides, if required, the factors necessary to adjust the handbook's standard meteorological day data

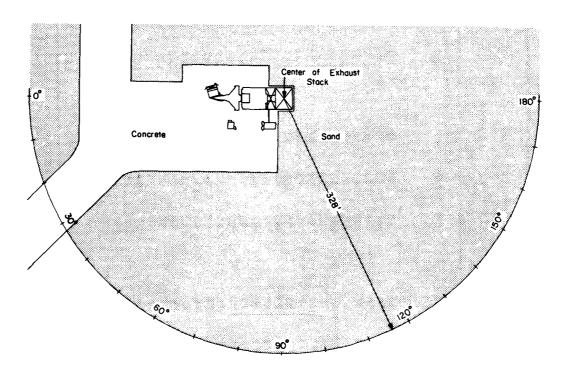


Figure 2. Far-Field Measurement Locations at Hill AFB, Utah

TABLE: MEASURED 2 1/3 OCTAV	SURED SOL OCTAVE E	N A NO	PRESSURE									OFFICE STATES	20 0
SOURCE/ AIRCR/ A-25 SU NO CRE!	SUBJECT SUBJECT SUBPRESS	THE OR LEVELS		OPERA Ball Call	TION: IDLE P 80% RP MILITA	3 E E	5% RPH) { (91% RPH) PWR				RUI DO C	7 T	-758-09 79 1
FREQ (HZ)	1/A	2/A	3/A		1/8	2/8	LOCATION/CONDITION 3/B 1/C	ONDITION 1/C	Z/C	3/6	1/0	2/0	3/0
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	75	2 2	8 8		) d	100	3 6	100	106	91	101	107	9
20	75	2	89		76	103	82	102		91	106	111	76
63	75	2	69		101	104	86	104		06	111		96
80	92	79	69		103	106	88	108		93	107		93
100	16	78	2		46	102	79	105		91	106		16
125	7.	77	29		95	66	82	100		87	104		8
160	79	83	29		76	98	7.8	96		48	104		88
200	4	80	99		96	100	87	101		80	102		95
250	92	11	69		93	4	81	66		87	104		92
315	81	78	69		95	46	<b>1</b> 2	100		86	103		96
007	80	79	99		91	96	75	103		87	108		<b>*</b>
500	83	82	70		86	95	78	105		88	110		93
630	95	91	77		96	96	8.2	106		88	113		<b>*</b>
900	96	ž	Z		101	101	83	107		90	113		95
1000	96	85	73		66	66	82	106		80	113		95
1250	90	89	75		66	100	82	107	108	88	114		95
9	<b>0</b> 6	89	74		100	101	96	105		88	113		96
2000	91	83	7		96	96	83	103		86	112		<b>*</b> 6
50	103	101	87		26	97	82	102		96	110		93
3150	66	26	81		86	86	81	102		86	109		36
0007	66	46	8		100	66	84	103		86	110		95
2000	4	96	90		107	103	87	102	103	86	108	111	96
6300	35	95	92		100	98	48	102		85	106		8
8000	95	93	11		100	66	498	100		87	105		88
10000	<b>4</b> 6	95	75		66	26	<b>5</b>	66		86	103		9
OVERALL	107	106	91		113	114	26	118	120	102	123	126	107
				1		1							

LEVEL CORRECTED TO REMOVE BACKGROUND/ELECTRONIC NOISE.

NOISE SOURCE/SUBJECT: F-16 AIRCRAFT IN THE AF32A-25 SUPPRESSOR GROUND CREW NEAR-FIELD NOISE LEVELS	/SUBJEC AFT IN UPPRESS W	T & THE OR LEVELS		OPERATION: A= IOLE PWR (6) B= 80% RPM C= MILITARY PWF	(65% RPM) PWR (91% NER PWR	(65% RPM) PWR (91% RPM) IER PWR				RUN 06 CUN		01 /R 79 J1
FREQ (HZ)	1/A	2/A	3/A	1/9	2/8	LOCATION/CONDITION 3/B 1/C	CONDITION	2/C	3/0	1/0	2/0	3/0
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	1/A	2/A	•	3/A		1/8	2/8	i <sup>—</sup>	LOCATION/CONDITION 3/8 1/C	DITION 1/C	5/C	3/6		170	2/0	3/0
HAZARD/PROTECTION C-WEIGHTED OVERA A-WEIGHTED OVERA NAXINUM PERMISSI NO PROTECTION	TION O OVERAL ENUSSION	33 <b>8</b>	SOUND	LEVEL	_	COASLC IN COASLA IN MINUTES)	088 088	NE A	EAR Ear Exposure	PER DAY	(AFR	161-35,	301.4	73)		
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BASED ON CALCULATED SPL SPECTRUM UNDER PROTECTIVE DEVICE. ADDITIONAL EAR PROTECTION REQUIRED.

#### **TABLE 4**

# TEST CONDITIONS FOR FAR-FIELD NOISE MEASUREMENTS

# F-16 Aircraft in the AF32A-25 Noise Suppressor, Ground Runup Hill AFB Utah, 14 March 1979

# Aircraft Engine Operation

Idle Single Engine 65 % RPM

440 F, Turbine Inlet Temperature

850 LBS/HR, Fuel Flow

80% RPM Single Engine

80 % RPM 650 F, TIT 3600 LBS/HR, FF

Military Power Single Engine

91 % RPM 920 F, TIT 8150 LBS/HR, FF

Afterburner Power

Single Engine 91 % RPM 920 F, TIT 38,000 LBS/HR, FF

## Meteorology

Temperature 12 C
Bar Pressure .643 M Hg
Rel Humidity 32 %

Wind — Speed 4 M/Sec (8 Kt)

- Direction 110 Deg

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NOISE SOURCE	18	1.13		90	OPERATIONS	į		1		) HET	ETEOROLOGY	06 Y B						-	7 <b>8 - 8</b> 5
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AF32A-25 SUPPRESSOR	UPPRES	SOR		_	SINGLE ENGIN	ENGI				<b>⊕</b>	BAR PR	PRESS =	• 64	3 H HG	CD.	3 22	MAR	49	
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04	58	61	9	61	<b>\$</b>	62	62	63	9	99	29	62	23	61	60	9	61	59	59
20	61	93	61	53	9	60	62	<b>6</b> 2	59	29	59	9	57	23	23	96	53	26	5
63	63	61	29	61	61	58	9	59	60	99	61	9	9	25	26	21	26	26	9
90	62	65	99	99	<b>6</b> 2	60	60	61	19	29	63	9	61	9	23	<b>2</b> 3	29	57	70
100	63	61	49	<b>†</b>	99	65	99	9	61	99	9	23	9	99	<b>†</b> 9	99	29	40	49
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2500	68	<b>9</b> 2	71	71	68	65	62	65	60	55	51	25	53	20	* N	<b>;</b>	50	4	*
3150	61	65	99	<b>6</b> 2	62	20	26	61	63	53	<b>67</b>	64	<b>6</b>	<b>*</b>	<b>1</b>	39	<b>4</b> 6	35	3
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2000	53	28	23	54	25	48	47	64	20	<b>†</b>	38	34	32	34	32	31	30	23	2
6300	64	26	S	4	7	<b>4</b>	42	<b>*</b>	<b>‡</b>	36	32	28	23	22	56	22	22	56	23
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10001	45	64	4	41	39	36	33	35	32	82	22	23	23	23	22	22	21	<b>5</b> 6	20
OVERALL	75	76	•	,	1														
		•	0	و	22	73	23	72	73	92	71	7	69	71	69	20	71	99	22

LEVEL CORRECTED TO REMOVE BACKGROUND/ELECTRONIC NOISE.

ıs.	_	3 @	FET	ERS	1 2 4 5 1												MEGA	4	
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31.5	8	80	78	92	7.4	72	74	68	69	71	20	7.	75	7.8	79	77	80	79	8
0 4	4	90	11	74	74	7.7	92	29	20	69	29	11	1,2	74	74	2	25	77	76
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	81	7.8	92	73	7.1	20	7.8	68	2	11	4 2	7.	92	11	22	22	7.	75	75
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315	7.1	73	89	65	29	19	65	23	23	53	59	25	28	29	29	<b>6</b> 4	9	62	39
400	68	69	<b>6</b> 2	65	<b>6</b> 2	53	63	23	58	25	25	55	57	55	28	29	57	57	53
500	99	29	65	49	61	58	63	28	26	55	53	25	ņ	55	53	50 80	54	51	25
630	65	65	99	65	61	25	62	28	56	24	52	64	53	64	20	25	51	41	5
800	68	71	73	70	65	62	29	9	56	<b>2</b> 9	21	23	22	25	51	26	25	<b>\$</b>	50
1000	99	69	68	67	61	23	99	61	60	21	21	51	23	09	20	<b>5</b>	51	<b>8</b>	40
1250	61	65	65	63	28	53	62	60	23	26	S	51	22	25	<b>4</b>	21	<b>4</b>	<b>\$ \$</b>	4
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2000	9	99	65	79	29	53	99	62	9	25	55	25	53	53	24	41	42	41	42
2500	50	49	63	62	26	50	<b>†</b>	61	58	5	25	47	52	51	<b>4</b> 3	37	38	38	8
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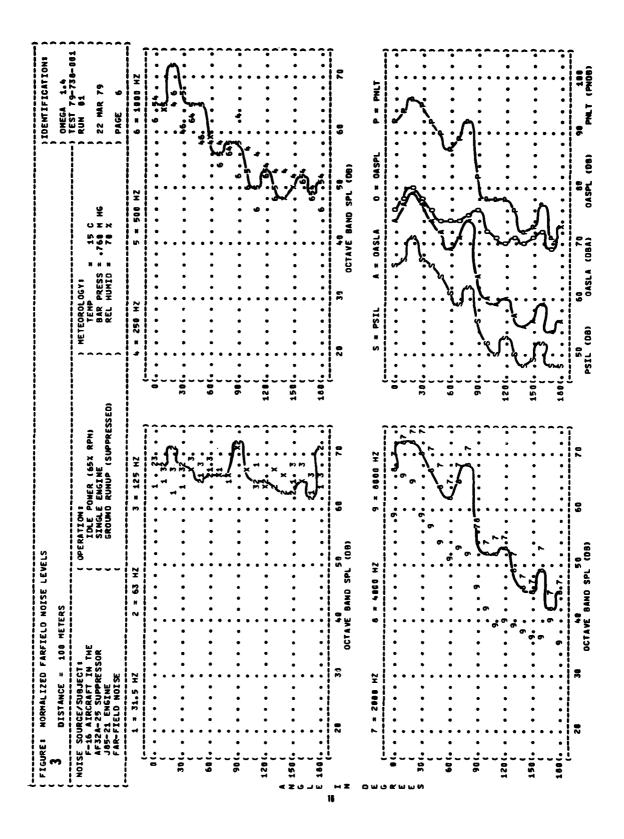
LEVEL CORRECTED TO REMOVE BACKGROUND/ELECTRONIC NOISE.

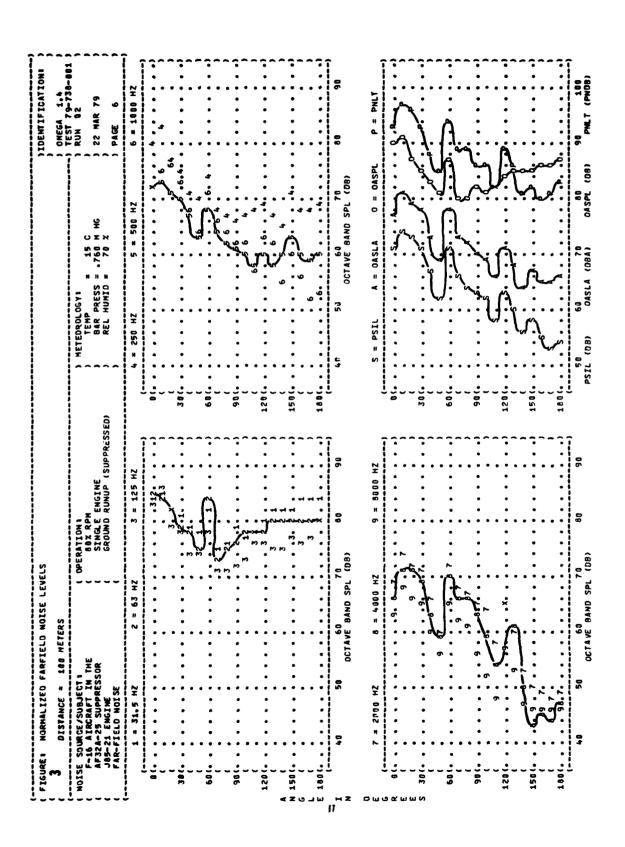
TABLE: 5	HEASURED S 1/3 OCTAVE DISTANCE =	75 W	SOUND F BAND	PRESSURE		ٔ ب	(08)			1									TCAT	NO.
NOISE AF32 J85-	ISE SOURCE/SUBJECT! F-16 AIRCRAFT IN THE AF32A-25 SUPPRESSOR J85-21 ENGINE FAR-FIELD NOISE	UBJEC IN PRESS ESE	7.7 3.8 8.8		0	PERATIONS MILITARY SINGLE ENG GROUND RUI	NE RY POWE ENGINE RUNUP	POWER (GINE INUP (SL	R (91% RPH) (Suppressed	RPH) ESSED)	¥	HETEOROLOGY TEMP BAR PRESS REL HUMID	PRESS HUMID	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	NEX Nav	£		RUN ON SE MAR	7-13	
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ž	<b>S</b>	98	83	*	8	83	83	82	79	81	82	81	90 60	82	.# 60	8	96	87	87	96
in .	31.5	10	92	\$	83	81	9	77	16	22	22	79	62	<b>™</b>	63	8	98	90	98	87
ī	_	9 ¢	e E	2 °	T 4	9 C	6 6	2	9 <u>7</u>	<b>2</b> 2	9 2	9 2	7 % 5 %	7 4	2 Z	24	\$ K	\$ G	# # 60 <b>%</b>	¢ 20
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<b>3</b>	_	29	82	82	80	7.8	11	15	73	73	22	7.8	80	81	95	82	8	83	10	85
7	8 K	<b>.</b>	<b>*</b>	0 €	9 <b>4</b>	78	7,	*	73	25	2 2	4,7	6 4 6 4	<b>2</b>	9 8	<b>60</b> 4	8 8	<b>6</b> 7	2 to	9 4
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630	•	69	23	92	73	2	6.8	99	29	65	9	61	61	29	58	61	9	9	63	8
90	•	72	22	15	72	70	29	65	99	65	65	62	62	9	28	50	<b>28</b>	23	9	58
1000	•	69	72	73	7.0	29	<b>9</b>	63	63	61	29	29	23	28	26	57	26	57	59	58
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100	-	62	99	65	61	57	53	96	52	25	52	51	47	42	45	94	46	45	46	45
5000	•	28	63	62	29	24	20	53	20	14	4	45	<b>*</b>	9	41	45	42	41	<b>1</b>	9
630	•	52	S D	9	n N	2	47	20	9	<b>1</b>	<b>1</b>	4	39	37	38	38	38	37	37	37
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1000	•	,	21	25	48	\$ \$	\$	<b>4</b> 5	38	36	37	37	37	37	37	37	37	37	37	37
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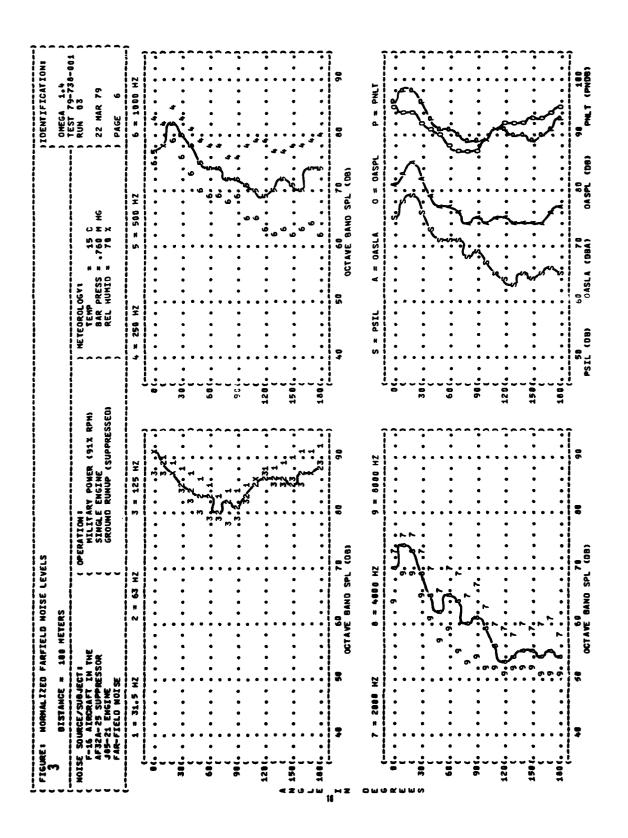
LEVEL CORRECTED TO REMOVE BACKGROUND/ELECTRONIC NOISE.

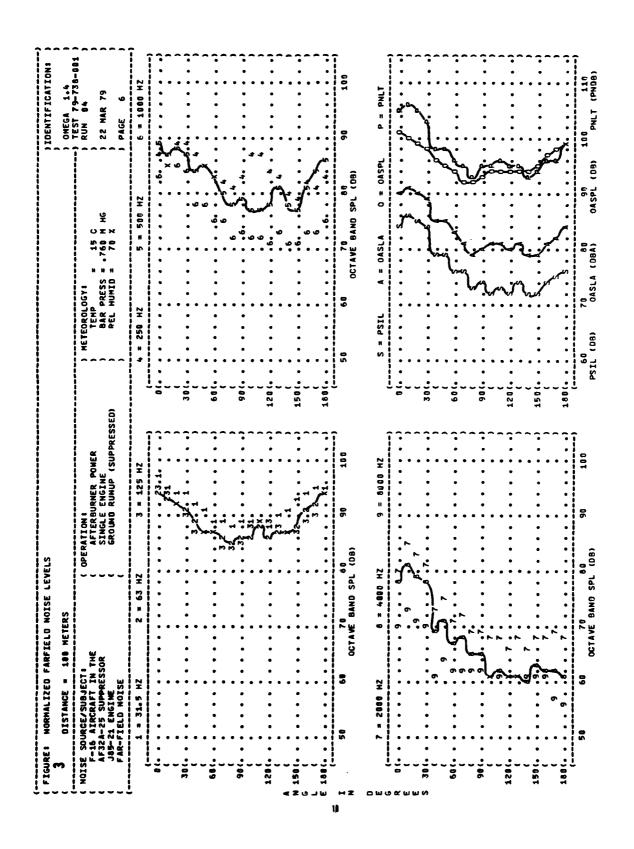
PECFORMER IN THE ( AFFRENCHER POWER ) HEFEGROLOGY I STUDENCE SOR ( GROUND RUNUP (SUPPRESSED) ) REL HUMID = 12 C C LD NOISE ( GROUND RUNUP (SUPPRESSED) ) REL HUMID = 32 Z LD NOISE ( GROUND RUNUP (SUP	ABLE:	_ <b>&gt;</b>	SA 4	PRES		EVEL	(08)											H 47	1CAT	ž č
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	OVERALL	100	66	96	4	35	96	93	36	91	36	93	<b>†</b> 6	93	93	93	95	96	97	66

LEVEL CORRECTED TO REMOVE BACKGROUND/ELECTRONIC NOISE.

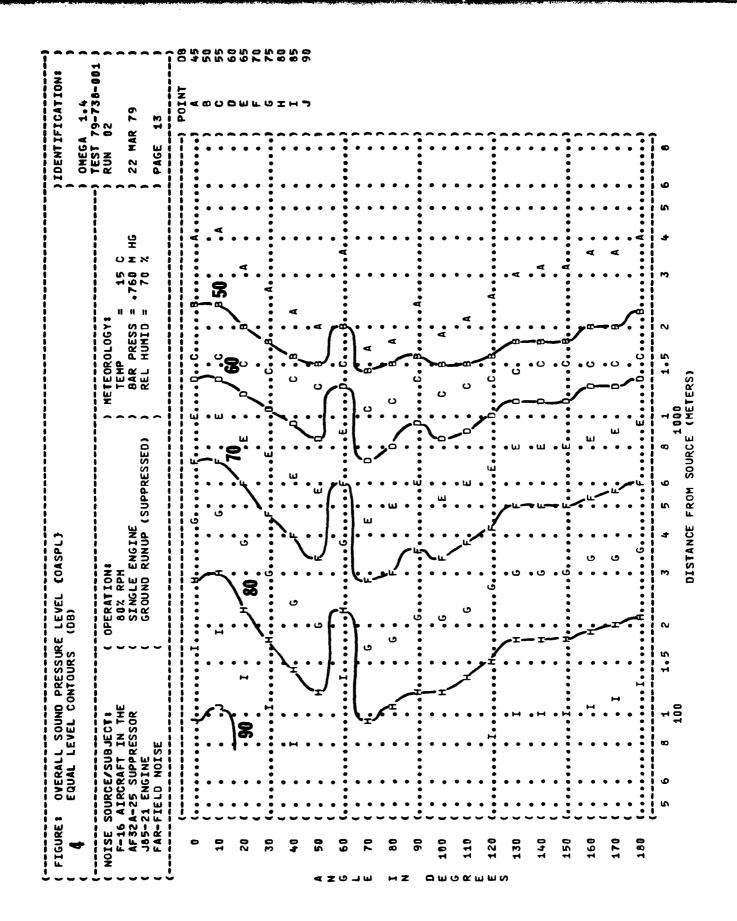


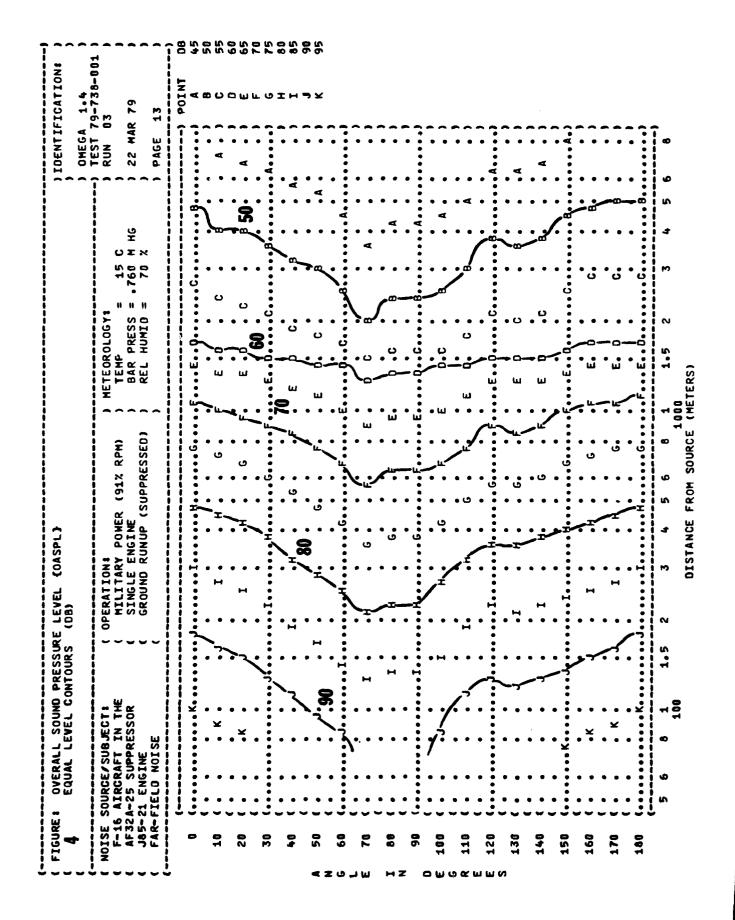


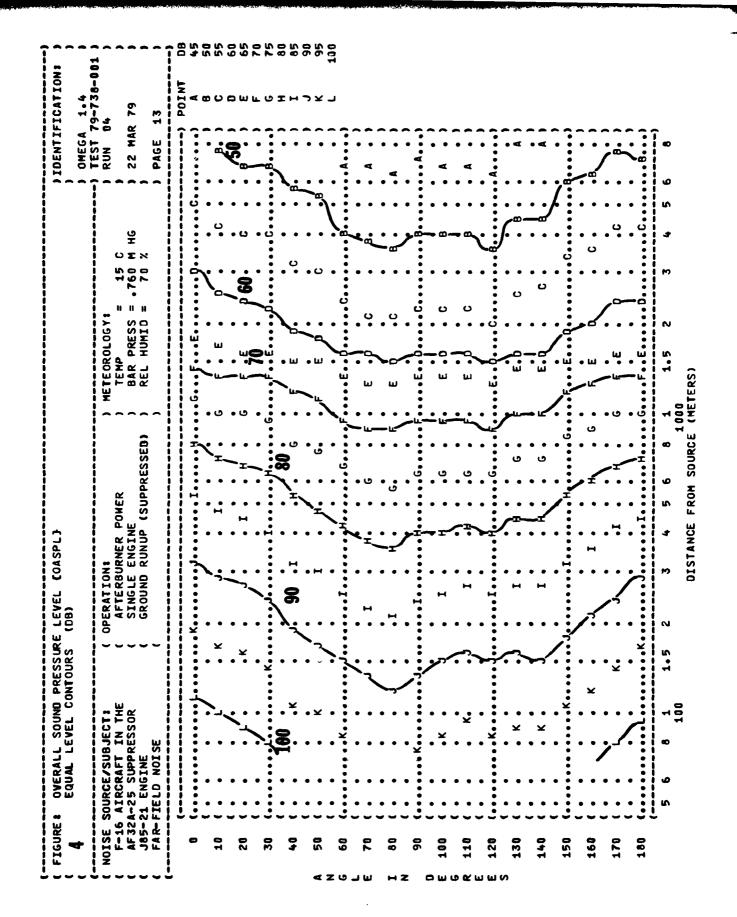


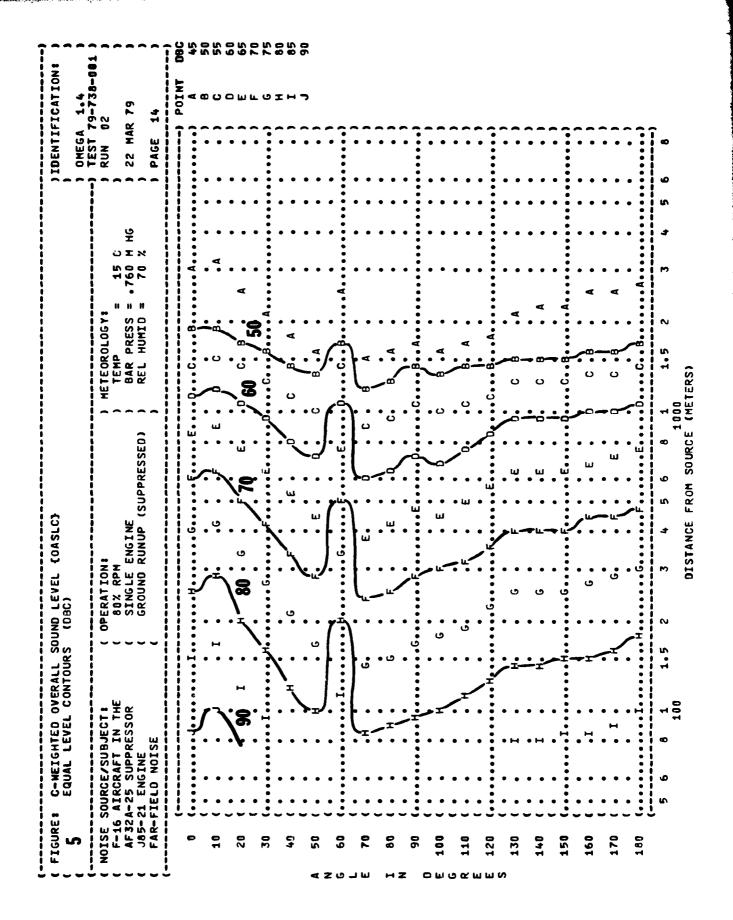


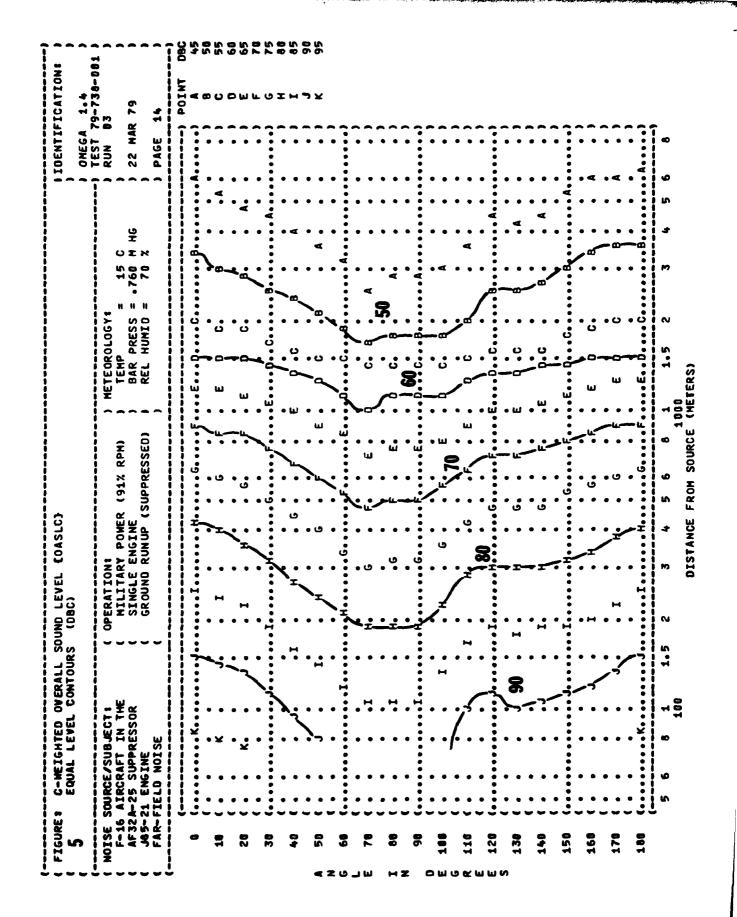
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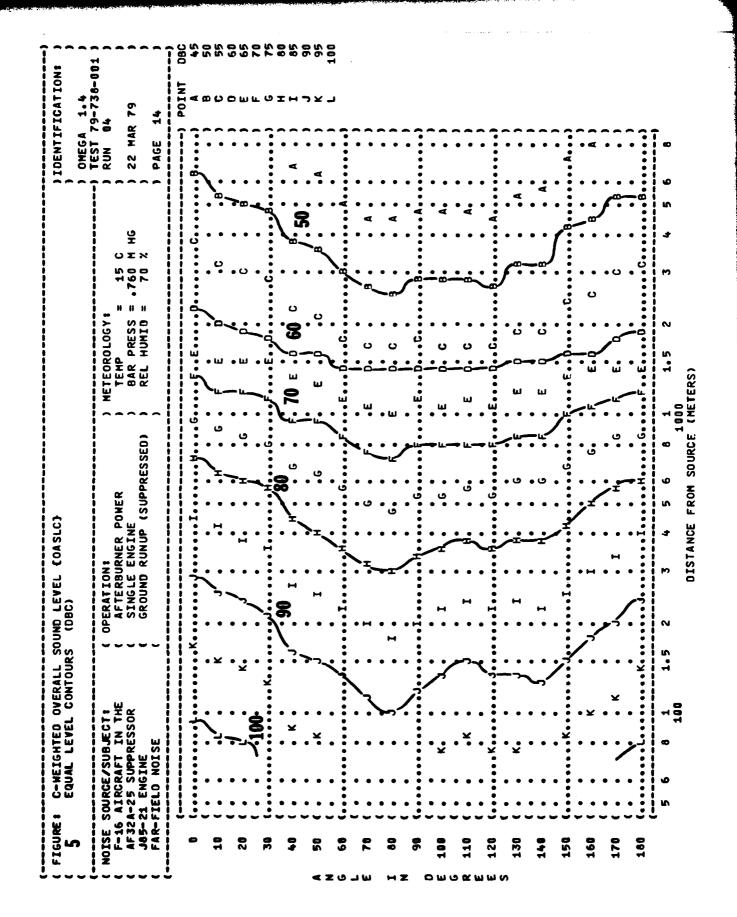










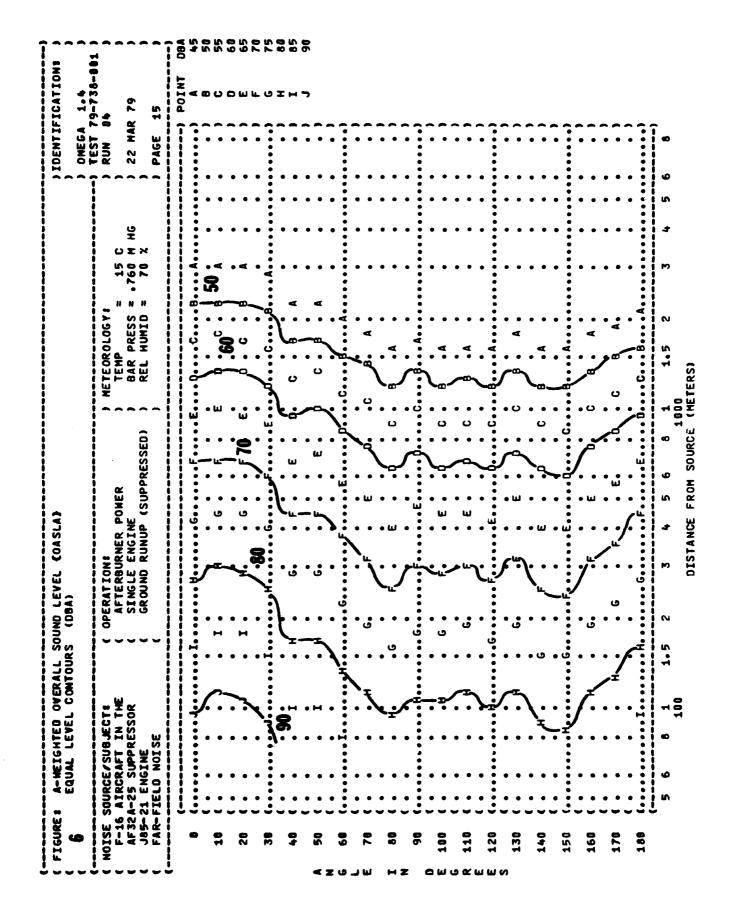


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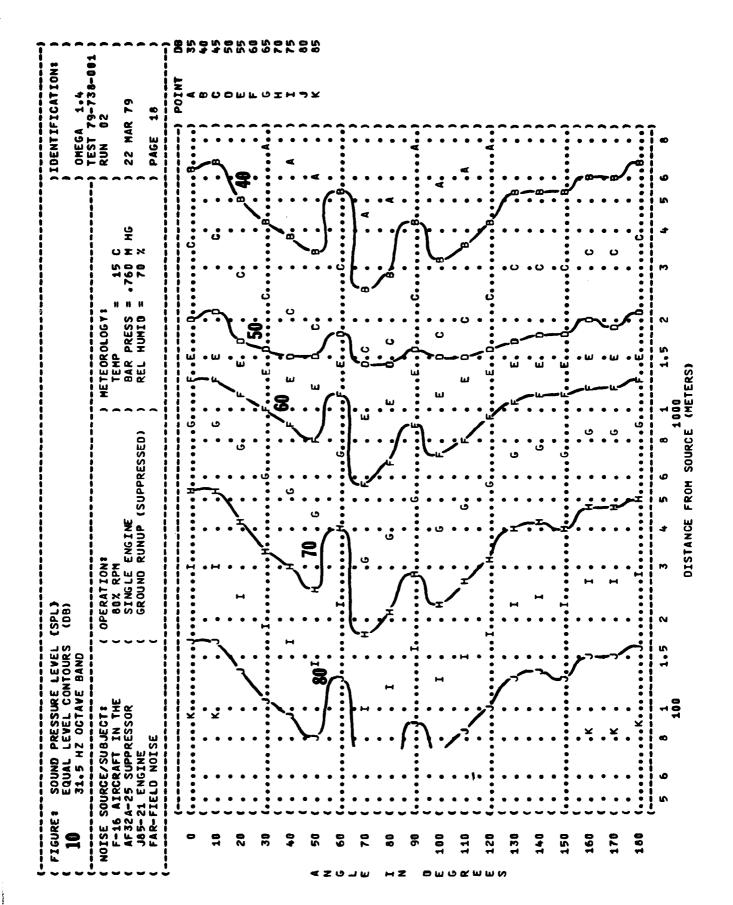
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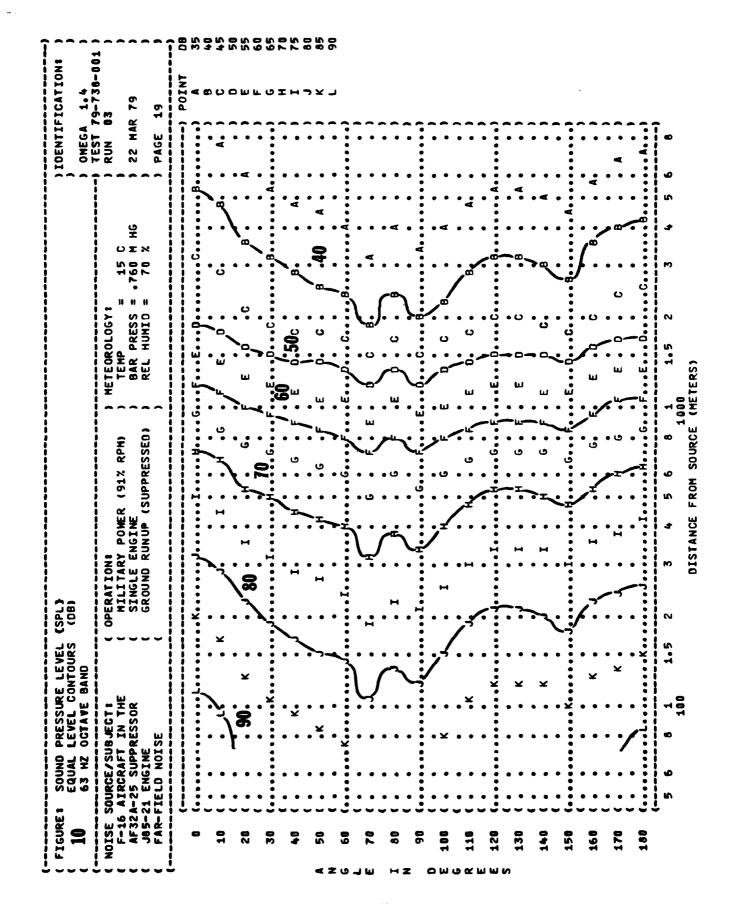
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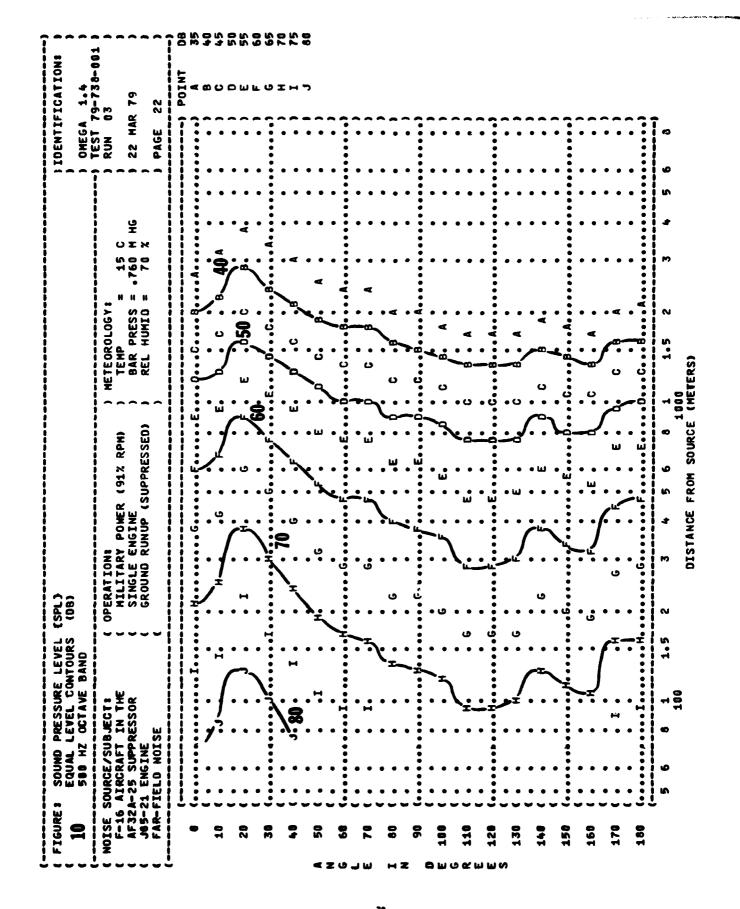
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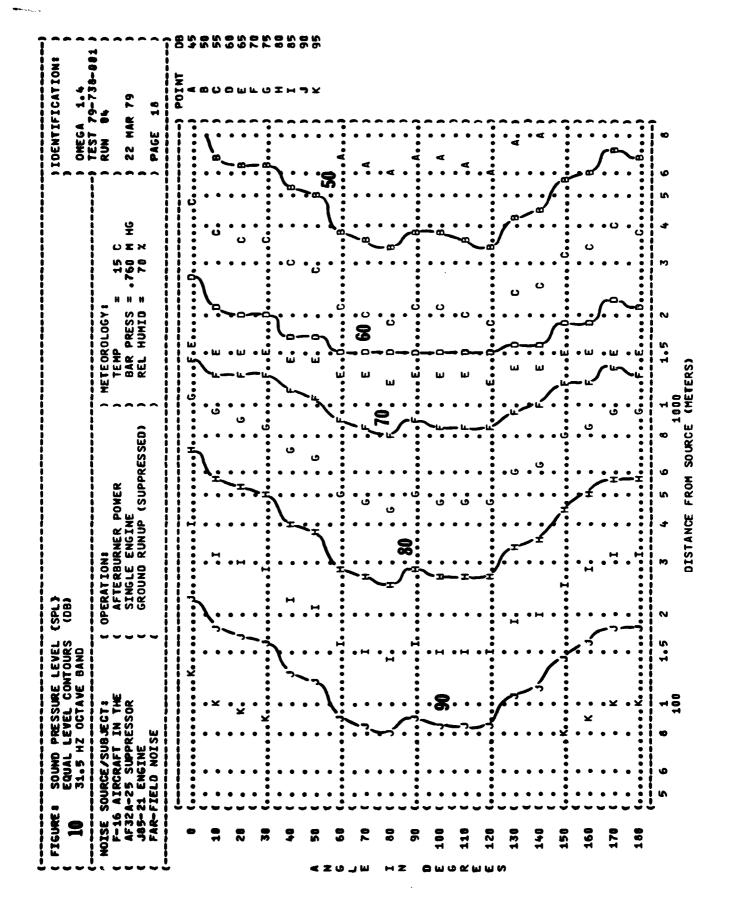
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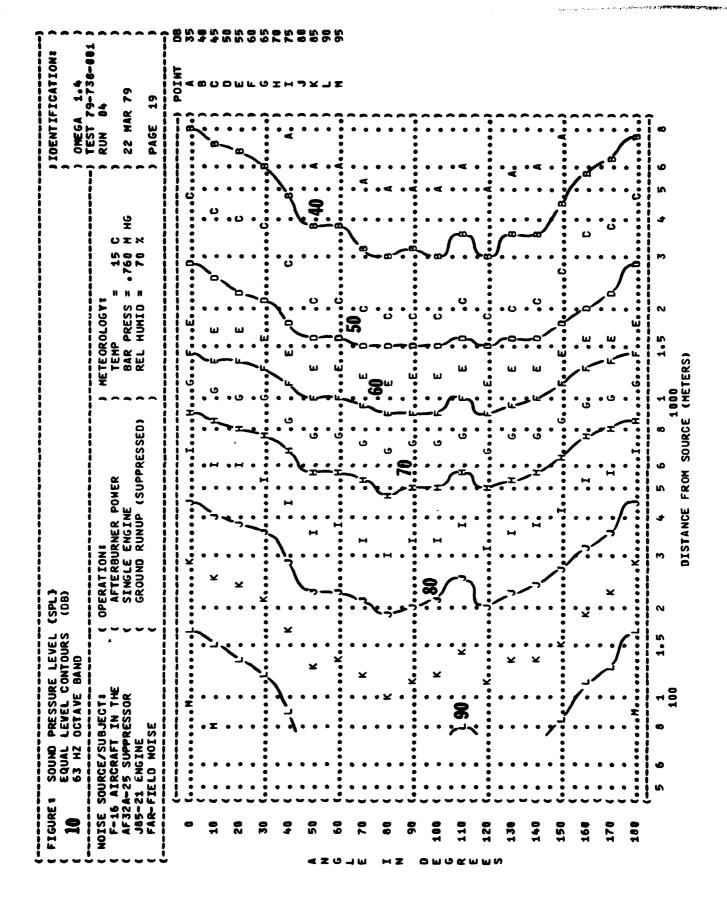


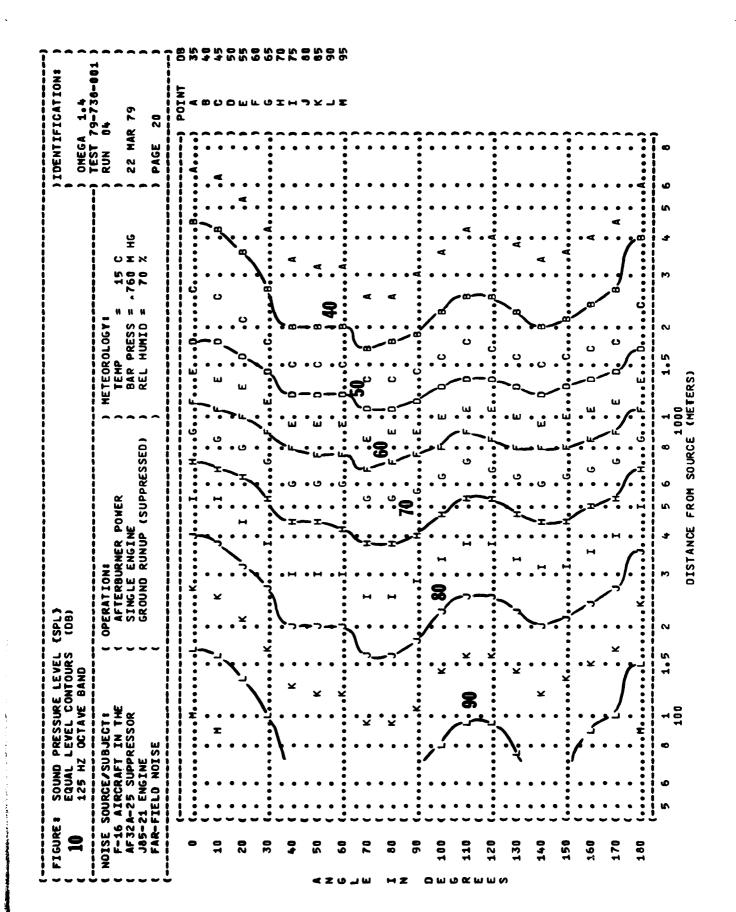
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